سكشن إتصالات : 5

Amplitude Modulation

→ Any Communication system Consists of:-

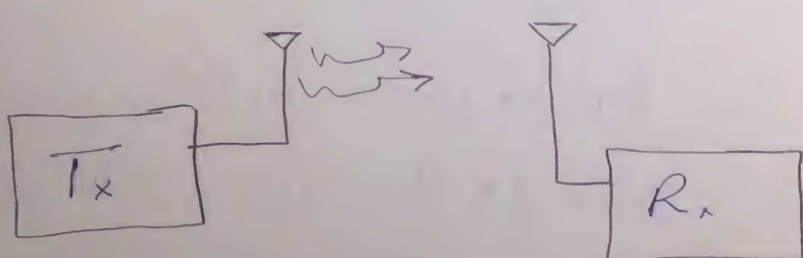
① Transmitter (T_x)

② Channel

③ Receiver (R_x)

→ A Transmitter sends amessage to the R_x via a channel.

* A voice message (human voice) has frequencies (300 Hz → 3-4 KHZ)



Wireless Comm. system
↳ Channel

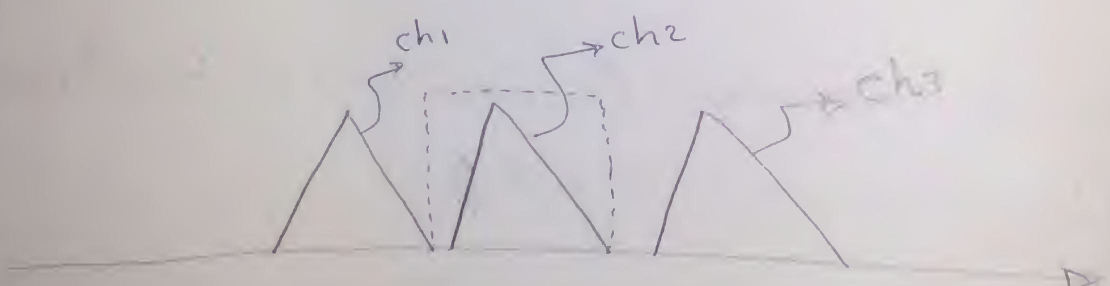
→ we Can't send the low freq. message directly because:

$\boxed{1}$ The wavelength (λ) is inversely Proportional to the freq ($\lambda = \frac{c}{f}$) & the length of antena ($L = \frac{\lambda}{4}$) so, the length will be very high & will reach several Kms.

For example

$$\lambda = \frac{3 \times 10^8 \text{ m/s}}{3 * 10^3} = 10^5 \text{ m} \Rightarrow L = \frac{\lambda}{4} = 25 \text{ Km}$$

$\boxed{2}$



In order to broad cast different channels, each channel should be on a different Position on the freq. axis, so the Rx Can choose one channel only at a time through the BPF.

$\boxed{2}$ Sec 6

Solution

① $m(t)$: message signal (voice)

low frequency signal

modulating signal

② $c(t)$: Carrier signal

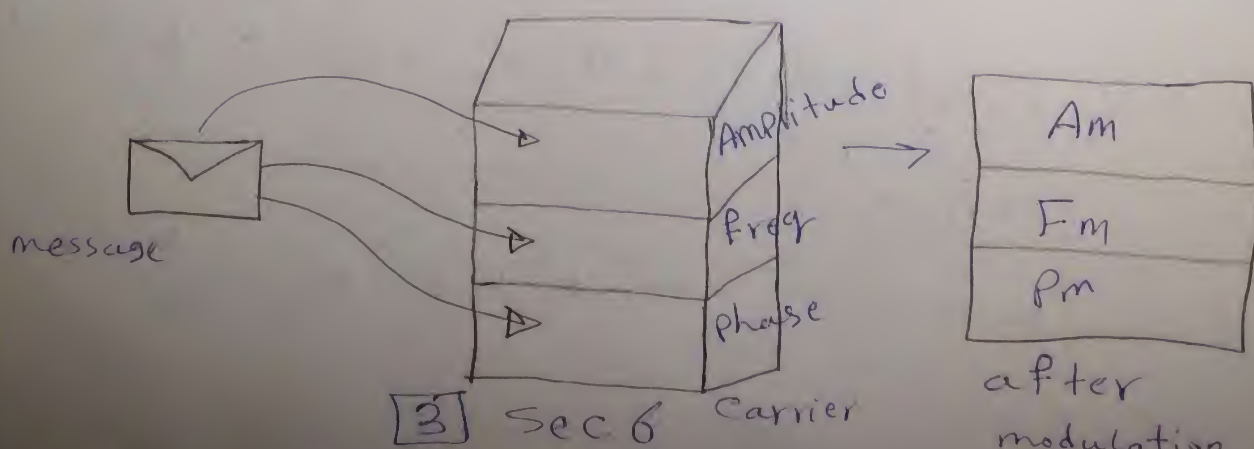
High freq. signal

③ $s(t)$: Modulated signal

بعد التعديل

$m(t)$: has low freq. modulates the $c(t)$ that has high freq. & the signal after modulation is called $s(t)$

$$c(t) = A_c \cdot \cos\left(2\pi f_c t + \underbrace{\phi_0}_{\text{phase}}\right)$$



AM

1 DSBTC

→ Double side Band transmitted Carrier.

~~2 DSBSC~~

2 DSBSC

→ Double side Band Suppressed Carrier.

3 SSB

→ single side Band.

4 VSB

→ vestigal side Band.

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1 DSBTC

$m(t)$, $c(t) = A_c \cos(2\pi f_c t)$

$$s(t) = A_c(1 + K_a . m(t)) \cos(2\pi f_c t)$$

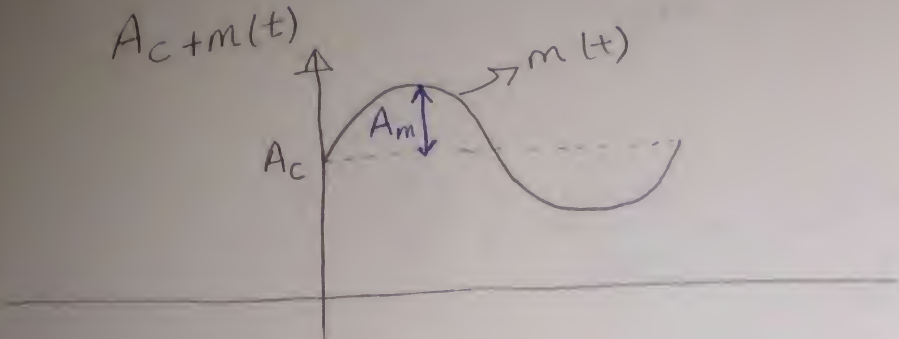
→ modulated signal.

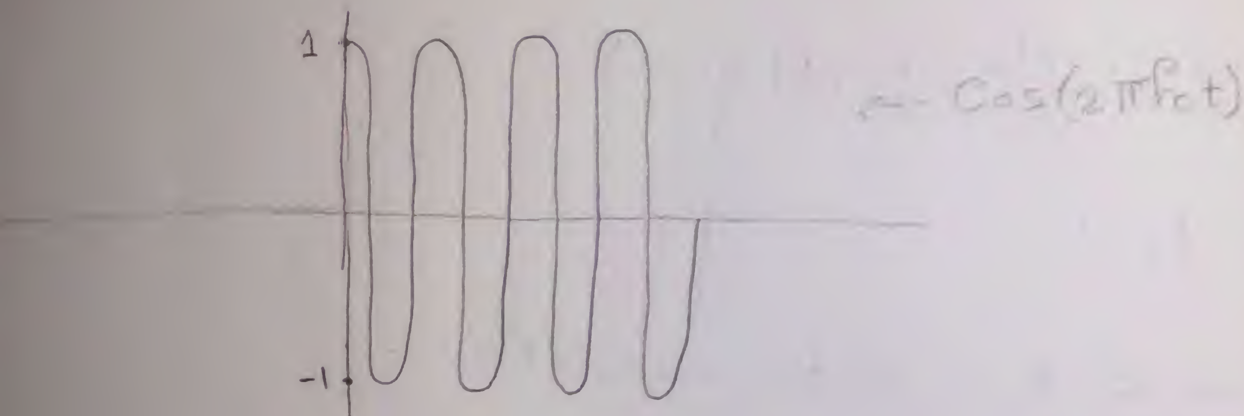
$$= \underbrace{A_c \cos(2\pi f_c t)}_{\text{Carrier}} + \underbrace{A_c K_a m(t) \cos(2\pi f_c t)}_{\text{message * Carrier}}$$

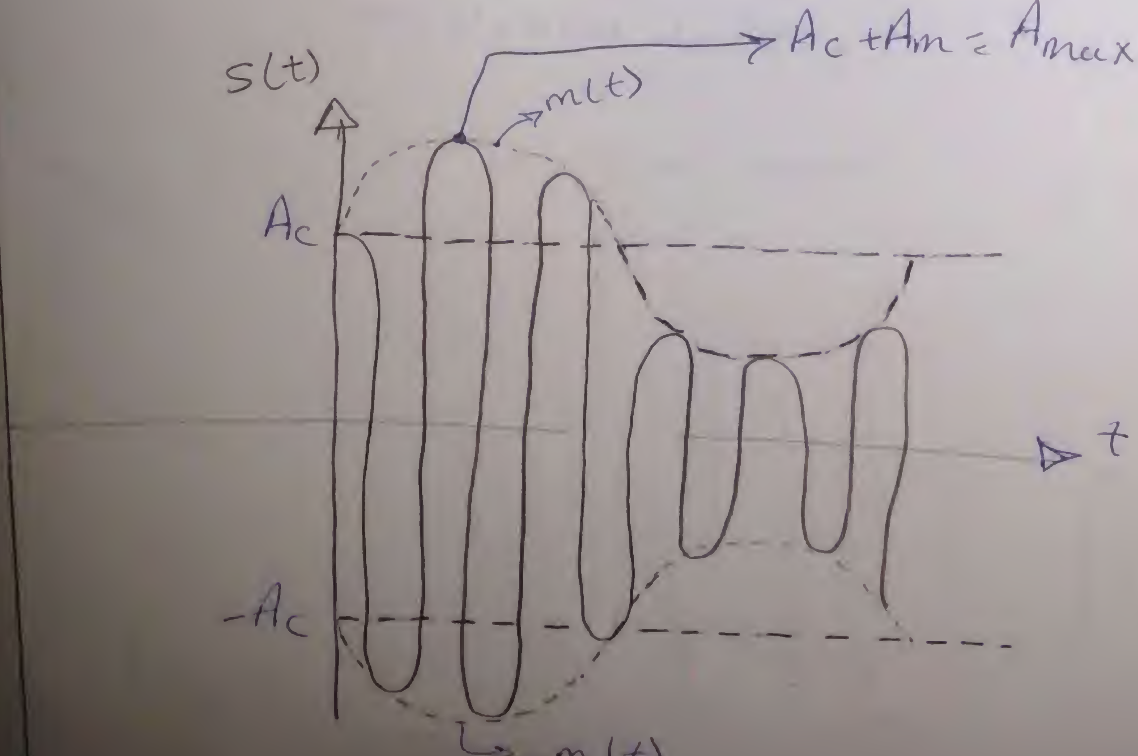
K_a → modulation sensitivity: $K_a = \frac{1}{A_c}$

$$s(t) = A_c\left(1 + K_a \cdot m(t)\right) \cdot \cos(2\pi f_c t)$$

$$s(t) = \left(A_c + m(t)\right) \cdot \cos(2\pi f_c t)$$







Modulation index (μ)

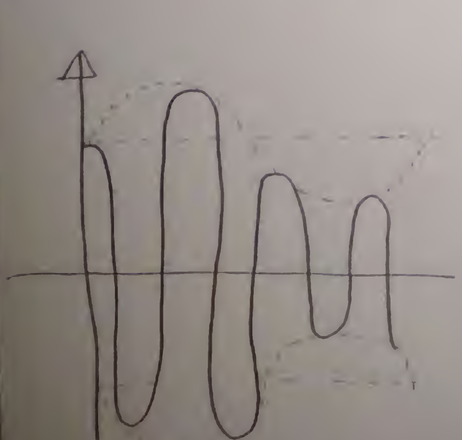
$$\mu = \frac{A_{max} - A_{min}}{A_{max} + A_{min}} \quad \text{or} \quad \frac{A_m}{A_c}$$

$$= \frac{A_c + A_m - A_c + A_m}{A_c + A_m + A_c - A_m} = \frac{2A_m}{2A_c} = \frac{A_m}{A_c}$$

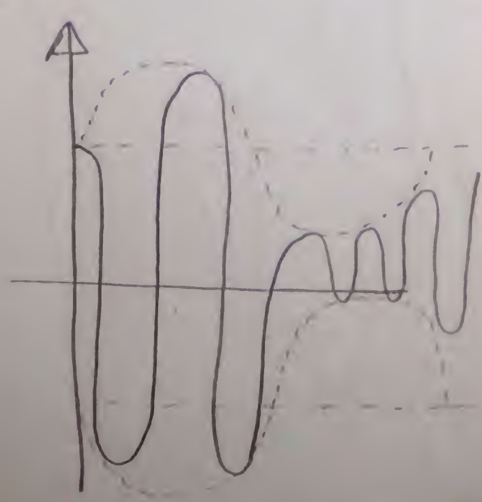
$$A_{max} = \left(1 + \frac{A_m}{A_c}\right) = (1 + \mu)$$

$$A_{min} = 1 - \mu$$

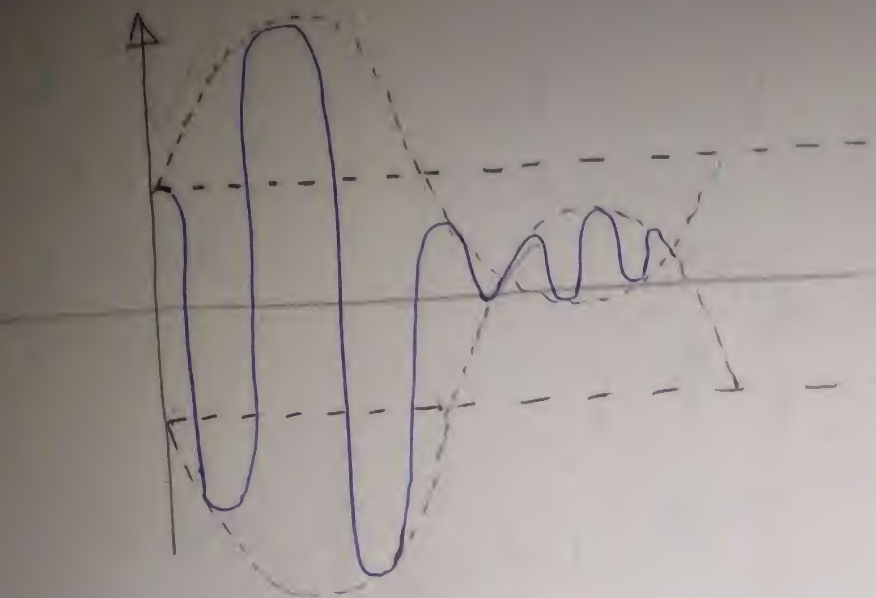
μ:
- < 1 under modulation.
- $= 1$ critical modulation.
- > 1 over modulation



$\mu < 1$
$A_m < A_c$



$\mu = 1$
$A_m = A_c$



$A_m > A_c$

$\mu > 1$

→ The best of them is under modulation.

$s(t) = A_c(1 + K_a \cdot m(t)) \cdot \cos(2\pi f_c t)$

* $f_m < f_c$

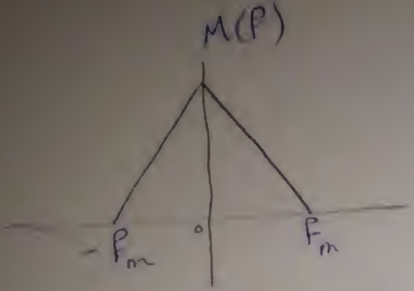
* $A_m < A_c \longrightarrow \mu < 1$

$s(t) = A_c \cdot \cos(2\pi f_c t) + K_a \cdot A_c \cdot m(t) \cdot \cos(2\pi f_c t)$

→ Fourier

$$S(f) = \frac{A_c}{2}\left[\delta(f - f_c) + \delta(f + f_c)\right]$$

$$+ \frac{K_a \cdot A_c}{2}\left[M(f - f_c) + M(f + f_c)\right]$$



Band width

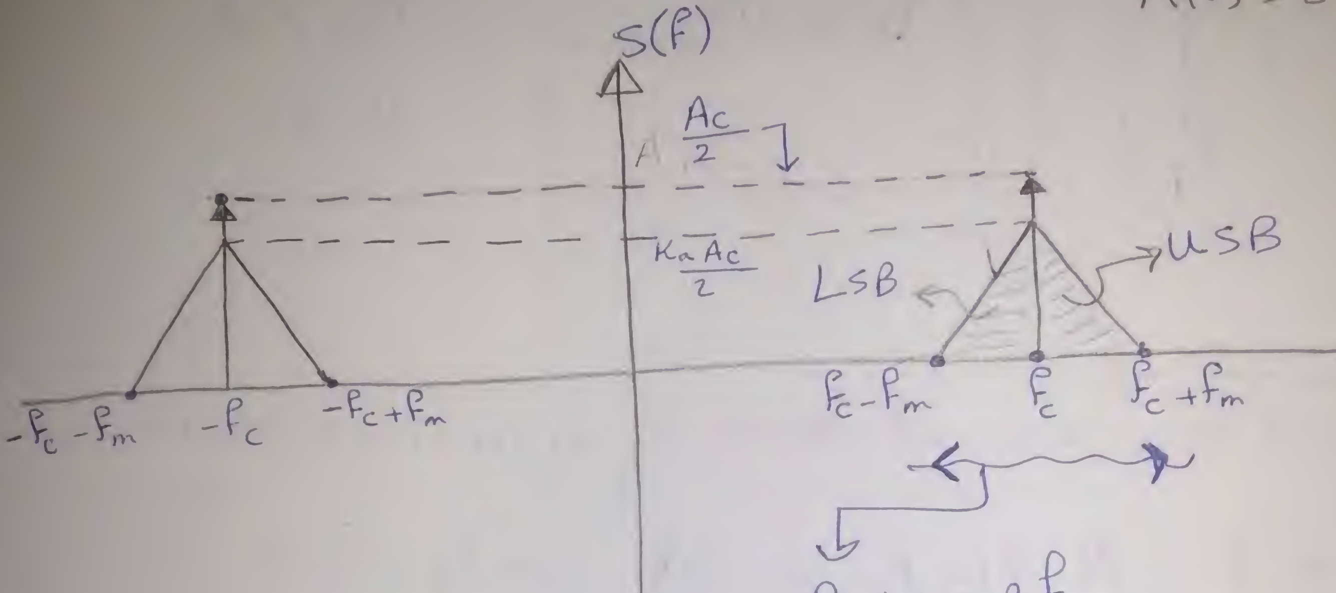
$\Rightarrow$ $B.w = f_m$

الجزء الموجب فقط

$M(f - f_c)$

at $f = f_c$

$M(0) = 2$



$B.w = 2f_m$

→ The B.w after modulation $= 2f_m$

which is a drawback because more B.w means more money to reserve this B.w.

← في الرسمة فيه USB ، LSB

USB → upper side Band

LSB → lower side Band

Modulation efficiency (η)

$$\eta = \frac{P_{useful}}{P_{total}} * 100$$

$$s(t) = \text{Carrier} + \underline{\underline{m(t)}} \cdot c(t)$$

P_{useful} ـــ المستخدمة لإرسال الرسالة ل Carrier.

$m(t)$

$$\eta = \frac{P_{DSB}}{P_{DSB} + P_c} * 100$$

For

$$m(t) = A_m \cdot \cos(2\pi f_m t)$$

$$c(t) = A_c \cdot \cos(2\pi f_c t)$$

$$s(t) = A_c(1 + K_a \cdot m(t)) \cdot \cos(2\pi f_c t)$$

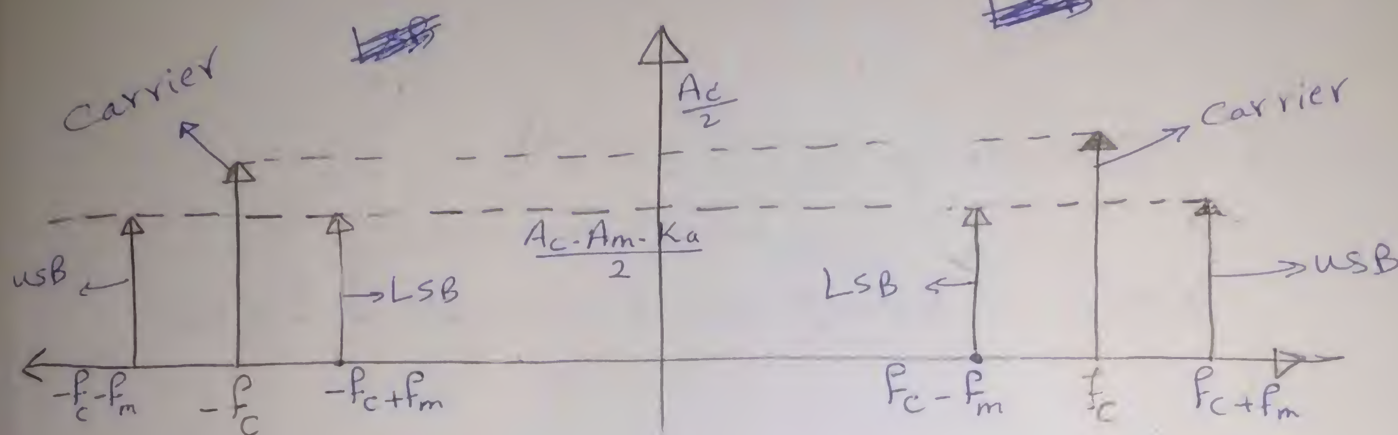
$$= A_c \cos(2\pi f_c t) + K_a \cdot A_c \cdot m(t) \cdot \cos(2\pi f_c t$$

$$s(t) = A_c \cdot \cos(2\pi f_c t) + K_a \cdot A_c \cdot A_m \cdot \cos(2\pi f_m t)$$

$$* \cos(2\pi f_c t)$$

$$s(t) = A_c \cdot \cos(2\pi f_c t) + \frac{A_c \cdot A_m \cdot K_a}{2} *$$

$$\left[\cos\left(2\pi (f_c - f_m) t\right) + \cos\left(2\pi (f_m + f_c)\right) t\right]$$



$$P_{avg} = \frac{1}{T_0} \int_0^{T_0} \text{signal}^2 \, dt$$

For sine, Cosine $\longrightarrow P_{avg} = \frac{\text{Peak}^2}{2}$

$$P_c = \frac{A_c^2}{2} \; ; \; P_{LSB} = \frac{(A_c \cdot A_m \cdot K_a)^2}{8} = P_{USB}$$

$\cancel{P_{DSB} = (A_c \cdot A_m \cdot K_a)}$

$$P_{DSB} = \frac{(A_c \cdot A_m \cdot K_a)^2}{4}$$

$$\mu = \frac{A_m}{A_c}$$

$$K_a = \frac{1}{A_c} \quad , \quad \mu = K_a \cdot A_m$$

$$P_{DSB} = \frac{\mu^2 \cdot A_c^2}{4} \quad , \quad P_c = \frac{A_c^2}{2}$$

$$\eta = \frac{\frac{\mu^2 \cdot A_c^2}{4}}{\frac{A_c^2}{2} + \frac{\mu^2 \cdot A_c^2}{4}} \qquad \div A_c^2$$

$$\eta = \frac{\mu^2 / 4}{\frac{1}{2} + \mu^2 / 4} \Rightarrow \eta = \frac{\mu^2}{\mu^2 + 2} * 100$$

$$P_t = P_c + P_{DSB} = \frac{A_c^2}{2} + \frac{\mu^2 A_c^2}{4}$$

$$P_t = \frac{A_c^2}{2}\left[1 + \frac{\mu^2}{2}\right]$$